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Summertime population density of *Rana temporaria* in a Finnish coniferous forest

Seppo PASANEN, Pia OLKINUORA & Jorma SORJONEN

Department of Biology, University of Joensuu,
Box 111, 80101 Joensuu, Finland

In this study, two methods were used to determine the distribution and the density of the frog population in a dry coniferous forest near a site where thousands of frogs winter in the ponds of a gravel pit. The fence-with-traps method gives relative values (frogs/100 m/day) and the square method gives the number of frogs per area. These methods are suitable only for mature and large immature frogs because small immature frogs (snout to urostyle < 35 mm) were able to climb up along the walls of plastic buckets and fences used for trapping.

With the square method, 64-80 mature frogs/ha were captured in 1990. The fence-with-traps method showed that the population density was highest close to the wintering site (2.3 frogs/100 m/day at a distance of 50 metres) and decreased with the distance from it (0.17 frogs/100 m/day at a distance of 500 metres). This decrease of density was caused by lower numbers of immature frogs.

INTRODUCTION

A wintering and spawning site of the common frog (*Rana temporaria*, Ranidae) is located in an old gravel pit in Laikko, Rautjärvi, Finland (61°22'N, 29°17'E), as has also been mentioned in previous reports published in Finnish (PASANEN et al., 1989, 1990). The frog winters in Finland almost only in water environment (KOSKELA & PASANEN, 1974) The habitat of the common frog during its feeding period has been described as a meadow with luxuriant vegetation composed of tall herbs and grasses (e.g. LOMAN, 1976, 1981, 1984). In Laikko, however, dry coniferous forest surrounds the ponds of the gravel pit where thousands of frogs winter and spawn The nearest potential wintering and spawning sites are the lakes 700 metres from the gravel pit.

LOMAN (1976, 1981, 1984) has used the capture-recapture method for studying the densities of frog populations. The fence-with-traps method has been used to count migrating frogs in spring or in autumn (KOSKELA & PASANEN, 1974; PASANEN et al., 1989, 1990). The main material for this study was gathered using the fence-with-trap method. This method gives values of relative population density (e.g frogs/100 m/day). The aim of this study was to determine population density at different distances from the wintering site. In 1990 also the square method was used to determine population density as frogs/ha.

Table I. – Distances of the fences and of the squares from the wintering site of *Rana temporaria*, lengths of the fences and numbers of trapping days in 1989 and 1990.

Fence	Distance	Length	Days		Square	Distance	Days
			1989	1990			1990
I	50 m	250 m	49	30	A	100 m	42
II	250 m	200 m	32	23	B	200 m	40
III	450 m	400 m	40	0	C	300 m	40
IV	500 m	400 m	25	0	K	120 m	34

Material and methods

In the study area, frogs spawn usually at the end of April or in the beginning of May, and the migration to the wintering site takes place in September and October. In the spring of 1989, when they started to move from the wintering and spawning pond, 2042 (977 mature and 1065 immature) frogs were marked collectively by toe-clipping. In 1989, four fences-with-traps (Koskela & Pasanen, 1974) were built to study the dispersion of frogs from the gravel pit (fig. 1, Table I). The fence was made of a 30 cm high plastic sheet stretched vertically between wooden sticks without any horizontal part on the top. The lower edge of the sheet was covered by moss to provide a tight seal against the ground. Buckets (diameter 25 cm, depth 22 cm, angle 95°) were buried into the soil at 10 m intervals along the fence which crossed in the middle of the buckets, so that frogs from both sides were able to fall into the buckets

The total trapping period in 1989 lasted from the end of May to the beginning of August. The buckets were examined and emptied almost every other day. In 1990, only fences I and II were used during June-July.

All frogs caught in the buckets during summer were measured (from the snout to the end of the urostyle). The material was grouped as follows: immature specimens (length smaller than 64 mm) and mature individuals (length greater than 64 mm) according to Koskela & Pasanen (1974). The frogs were marked collectively by toe-clipping (the same toe for all summer captures, but not the same toe as in the spring) and the adults were also sexed The frogs were then set free 2-3 metres from the pitfall haphazardly on either side of the fence. The results are given as number of frogs per 100 metres of fence in 24 hours (frogs/100 metres/day).

In June 1989, seven 10 × 10 metres squares were built at the distance of 350-400 metres from the wintering pond between the fences II and III (fig. 1). The fence was again 30 centimetres high and every square had one bucket in each corner.

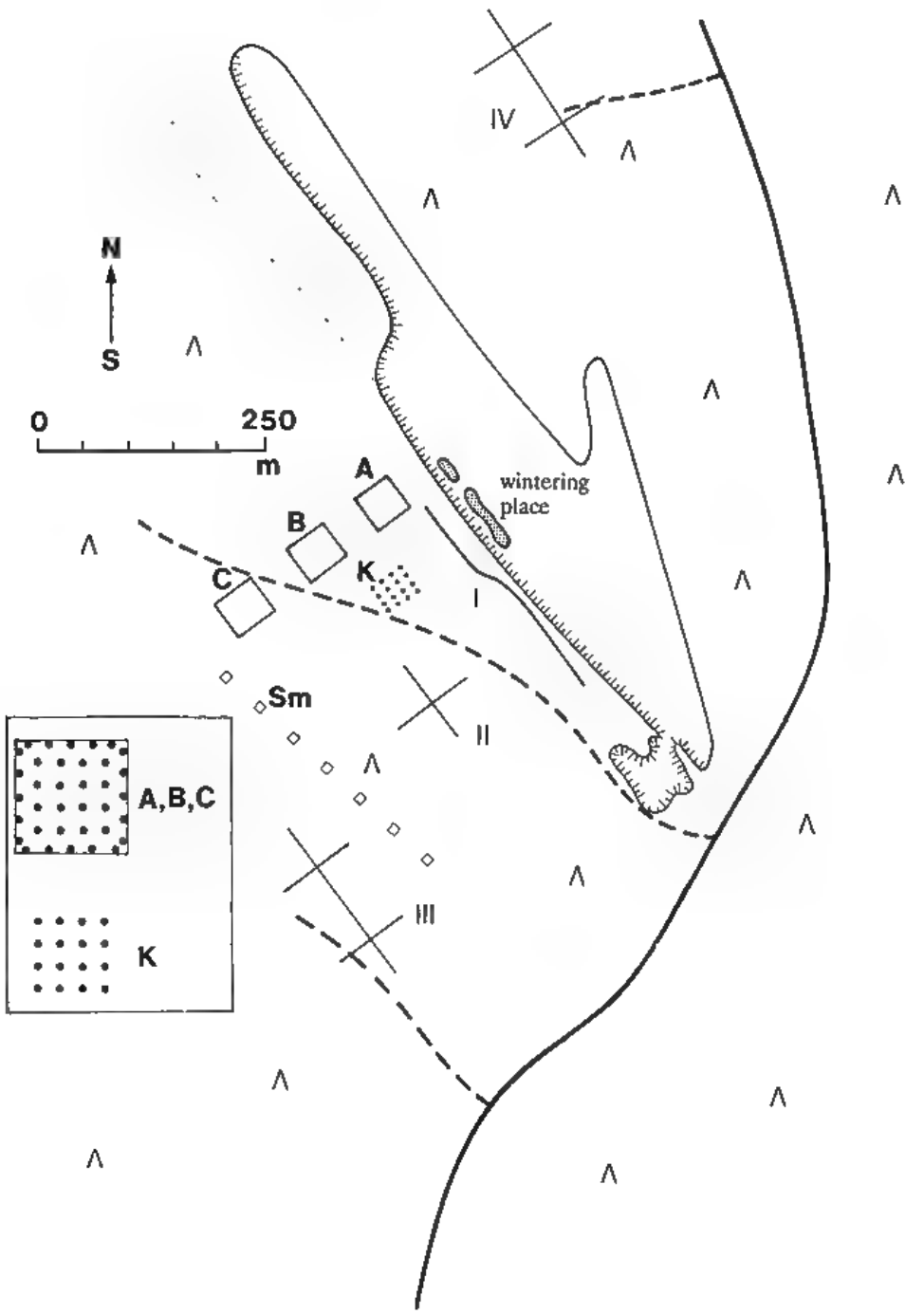
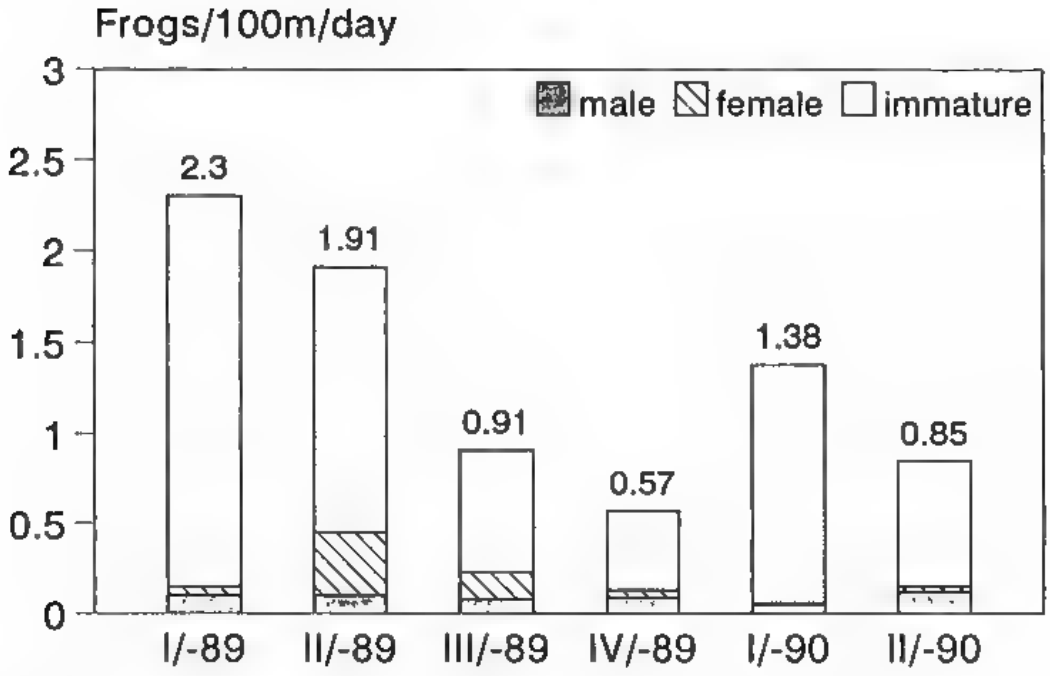


Fig. 1. – Map of the study area.
I-IV = fences-with-traps (buckets placed at 10 m intervals).
A-C = fenced squares (50 × 50 m, 36 buckets)*.
K – square without fence (16 buckets)*.
Sm = small squares (10 × 10 m).

* The small inset figure shows the location of buckets in squares A-C and K.



	I/-89	II/-89	III/-89	IV/-89	I/-90	II/-90
immature	2.15	1.46	0.68	0.44	1.32	0.7
female	0.05	0.35	0.15	0.04	0.01	0.03
male	0.1	0.1	0.08	0.09	0.05	0.12

Fig. 2. – Frogs caught with the fence-with-traps method in 1989 and 1990 on fences I-IV (see fig. 1).

In the beginning of June 1990, three 50 × 50 metres enclosures (A-C) were built to count natural frog density (fig. 1, Table I). The plastic fence was 50 centimetres high and the lower edge of the fence was buried 10 centimetres into the mineral soil. In each square, 20 buckets were buried along the fence (inside), and the inner part of the square was furnished with 16 buckets placed at a 10 m distance from each other. The control plot consisted of 16 buckets without a fence (square K) (see fig. 1).

Frogs were trapped in squares and at fences I and II from June 2 to August 10, 1990. The buckets were checked and emptied and the frogs were treated as in the previous summer. During autumn (September 18 – November 3, 1990), frogs began to gather into the side buckets of the squares on their way to the wintering sites. These frogs were counted and released outside the square. A total of 36 recently metamorphosed frogs were marked to control their possible crossing of a fence.

Weather conditions (temperature and humidity) were recorded with a Lambrecht-hydrothermograph during both summers. Mean daily temperature and mean daily relative humidity were calculated as the mean of four observations (00.00, 08.00, 16.00, 24.00 h) of the day before the catching day.

Table II. – Proportion of adults among frogs marked in the spring 1989 (977 mature, 1065 immature) and caught during the summer at fences I-IV.

Fence number	Recaptured (mature/immature)	Percentage of adult marked frogs
I	8/60	13%
II	6/23	25%
III	16/20	81%
IV	6/8	83%

RESULTS

The total number of frogs caught in the summer of 1989 was 555 (85 mature and 470 immature). The number of immature frogs decreased significantly (Pearson's correlation, $R^2 = 12.36$, $P < 0.01$) as the distance from the wintering site increased (fig. 2) Most females were caught at fences II and III, while the number of male frogs was nearly the same at all four fences. In 1990, the actual number of captured frogs was 133 (10 mature and 123 immature).

The proportion of adult frogs marked in the spring of 1989 at the wintering site increased with increasing distance from the gravel pit (Table II). Of the 555 frogs caught and marked at fences I-IV in the summer of 1989, only 29 individuals (5 %) were recaptured in the same summer and none in 1990 Recaptures were more common among adults (14 %) than among immature frogs (3 %).

In the small squares (10 × 10 metres), 0-2 mature frogs were found per square (mean = 1.29, S.E. = 0.29, n = 7), which would make 129 frogs/hectare. In the large (A-C) squares, 10-17 frogs/square were caught in summer and 16-20 in autumn (Table III). All frogs marked inside the squares during summer and three to six unmarked frogs/square were found in the autumn. They did not fall into the traps during summer, even though the trapping period lasted 40-42 days The total number of mature frogs/ha varied from 64 to 80.

Small immature frogs (juveniles in their first year, snout to urostyle < 35 mm) were able to climb up along the walls of the plastic buckets and fences. This was indicated by the marked frogs and the increase in the number of immature frogs caught during summer. Eight (24 %) of the 36 small frogs marked in autumn and released outside the squares were found again inside a square later on. In the summer (at the beginning of metamorphosis), only 3-11 small frogs were found in the squares (12-44 immature/ha), but, during the autumn trapping, 140-190 small, recently metamorphosed frogs were captured per square (560-760 immature/ha) Although this method proved to be unsuitable for density

Table III. – Number of mature frogs in the squares.
Summer = catches in summer (including buckets along the fence and in the inner part of the square).
Autumn = catches in autumn.
Inner buckets = catches in the buckets in the inner part of the square in summer (number of catching days in parenthesis).

Square	Summer				Autumn			
	♂	♀	Σ	Inner buckets	♂	♀	Σ	Frogs/ha
A	13	4	17	6 (42)	15	5	20	80
B	10	4	14	8 (40)	12	7	19	76
C	10	0	10	5 (40)	13	3	16	64
K	1	0	1	1 (34)	-	-	-	-

estimation of the smallest frogs, it shows that in the autumn the immature frogs are abundant at a distance of hundreds of meters from their home pond.

No correlation was found between the activity of the frogs and weather conditions. Temperature apparently did not influence the activity of frogs during summer (1989 R^2 = 1.53, $P > 0.60$; 1990 R^2 = 1.76, $P > 0.60$), nor did relative humidity (1989 R^2 = 4.20, $P > 0.40$; 1990 R^2 = 10 94, $P < 0.25$).

Discussion

The fence with traps method is generally used to study frog migrations in the spring or autumn. In this study, we tried to use the method also to study the distribution and population structure. The method gives only relative results, but when several fences are used at the same time, the results are comparable. In this study we got clear results: the number of immature frogs decreases as distance from the wintering site increases, but equal numbers of mature frogs were found at different distances (fig. 2).

We used the square method in order to estimate the population density. These results (64-80 mature frogs/ha) agree with those of other studies. On meadows, the population density of *Rana temporaria* can be as high as 550-790 mature frogs/ha (Loman, 1976, 1981, 1984). In deciduous forests, it has been estimated that there are 125 mature frogs/ha (Glowacinski & Witkowski, 1970), and in coniferous forests 25-50 adult frogs/ha (Inozemtsev, 1969). The method used in the cited studies was capture-recapture. In the present study, a density of 100 frogs/ha is reached, if large immature frogs are included

(frogs longer than 64 mm were considered to be adults). Since the ground vegetation in Laikko is very poor and includes in many areas only mosses, the population density seems to be rather high for these conditions. In 1989 and 1990, nearly 3000 mature frogs were found to winter in the ponds at Laikko (PASANEN et al., 1989, 1990). If the population density around the gravel pit in summer remained constant (64-80 frogs/ha), 3000 frogs would require an area with a radius of 350-400 m.

In areas around a spawning pond, favourable conditions during spawning and the larval phase have a strong impact on population density (SAVAGE, 1961, LOMAN, 1978; CUMMINS, 1986). In Laikko, the ponds in the gravel pit are the only spawning places of the area. According to the density results, the number of frogs, especially young ones, decreases as the distance from the ponds increases Of all the marked frogs, the proportion of mature frogs was greater as the distance from the wintering site increased. This indicates that the spawning and wintering site is the core of the population, from which immature frogs gradually move farther away.

This type of population is quite vulnerable Spawning failure in one spring is not as dramatic as is failure to winter Wintering may be unsuccessful due to draining of the pond, for example, and this can cause the population to collapse for a long time. Catches for the years 1989 and 1990 were different: in 1989, there were many more immature and female frogs than in 1990 (fig. 2). This raises the question: is it possible that frogs — especially female and immature frogs — could also winter on the ground, when the soil doesn't freeze deeply?

In square K were captured only one mature frog, while in the corresponding buckets of the inner part of squares A-C there were 5-8 frogs. Obviously the fence confuses the frogs, and a 50 × 50 m square is therefore too small for studying their movements. On the other hand, many frogs do not move enough during the whole summer to fall into a bucket (Table III).

The square method is good for estimating population density of the frogs. With 10 × 10 m squares, mere chance determined whether there were two frogs, one frog or none inside a square. Squares of 50 × 50 m, however, seemed to be suitable in this biotope. When population density is high, it may also be possible to obtain reliable results with smaller squares. We recommend to build squares in late summer and to do empty-catching during the autumn migration of the frogs, no buckets are needed in the inner part of the square. The observation that young frogs which have not yet wintered are able to climb over a plastic fence and up the sides of a bucket decreases the usefulness of these methods, which are suitable only for mature and larger immature (> 35 mm) frogs.

In many studies, correlations between temperature and humidity and the activity of frogs were observed (BELLIS, 1962, DOLE, 1965; ASHBY, 1969, LOMAN, 1979; WOOLBRIGHT, 1985). In this study, we could not find any correlation between weather conditions and movements of the frogs. A possible explanation is that the buckets were usually examined every second day and the long period between examinations covered the correlation. Thus the buckets ought to be examined at least once a day.

Résumé

Dans cette étude, deux méthodes ont été utilisées pour déterminer l'activité et et la densité d'une population de grenouilles dans une forêt de conifères assez sèche près d'un site où des milliers de grenouilles hivernent dans les étangs d'une gravière.

La méthode qui fait appel à des pièges placés le long d'une barrière donne des valeurs relatives (grenouilles/100 m/jour). La méthode des carrés donne le nombre des grenouilles par surface Ces méthodes ne conviennent que pour l'étude des grenouilles de taille importante, car les petits spécimens encore immatures (< 35 mm) sont capables de grimper le long des seaux en plastique et le long des barrières utilisées pour les piéger.

En 1990, avec la méthode des carrés, 64 à 80 grenouilles matures ont été piégées par hectare. La méthode des barrières a démontré que la densité de la population était la plus grande près du site d'hibernation (2,3 grenouilles/100 m/jour à une distance de 50 mètres), et que cette densité diminuait avec l'augmentation de cette distance (0,17 grenouilles/100 m/par jour à une distance de 500 mètres). La baisse de la densité totale est causée par une diminution de la densité des jeunes grenouilles quand la distance augmente.

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